REMARKS

Upon entry of this amendment, claims 30-68 will be active in this application.

Applicant's undersigned representative would like to thank Examiner S. Mark Clardy for the helpful Mar 31, 2004 discussion of the issues in this application. Applicant's representative respectfully submits that in light of the following amendments, remarks, and additional information submitted herewith, this application is in condition for allowance.

As discussed with Examiner Clardy, the present invention relates to Applicant's discovery that a certain zeolitic material (termed "Yenomite" in the application) exhibits a number of important advantages when it is added to soil, *i.e.*, when it is used as a soil amendment. As also discussed with Examiner Clardy, Applicant has added claims in this application to (i) reducing the release of fertilizers into the environment and (ii) improving the efficiency of water used in growing agricultural or horticultural plants.

The advantages obtained by using Yenomite as a soil amendment include:

1. growing healthier agricultural or horticultural plants bigger and faster,[1]
2. preventing fertilizer seepage into the environment, including the ground water,[2] and
3. more effective use of irrigation (or rain) water.[3]

These advantages are seen from a number of sources. A copy of each of these is submitted herewith. Their content is summarized below.

The specification:

The example provided at page 26 to 28 of the specification show some of the remarkable results provided by using Yenomite. In the first example, it was observed that when Yenomite

[1] See page 10, lines 7-10 of the specification.
[2] See page 4, lines 10 and 11, and page 9, lines 13-21 of the specification.
[3] See page 11, lines 23-26 of the specification.

was added to a peat-based growth media typical for the production of vegetable seedlings in greenhouses:

1. tomato seedling size is increased by 3 to 47.3% regardless of "organic" or mineral nitrogen fertilization, and

2. cauliflower seedling size was similarly increased from 18 to 160%.

In the second example, the use of Yenomite in a clay soil in a greenhouse culture of tomatoes and lettuce provided:

1. an increase in lettuce yield of 8.5 to 91.7%,

2. an increase in tomatos of 13.5 to 73.6%, and

3. important improvements in water use efficiency.

These tests show that Yenomite provides increased yields for both conventional and "organic" growers. This faster growth yields marketable plants sooner or bigger, more attractive plants in the same amount of time – or less.

Dr. Wayne Kussow's "First Annual Report"[4] (Exhibit 1):

This report, which reports work done by Dr. Wayne Kussow of the University of Wisconsin, provides a comparison of the performance of different growing soil amendments on turfgrass. Two of these soil amendments contained zeolites: Agriboost (*i.e.*, Yenomite)[5] and GSA (another zeolitic material).[6]

Dr. Kussow's report provides the following information:

1. AgriBoost (*i.e.*, Yenomite) had a CEC (cation exchange capacity) that was almost twice that of the other zeolitic amendment tested, GSA. See Fig. 4 of the report and the text

[4] For completeness' sake, a copy of Dr. Kussow's "Research Proposal" is also being submitted herewith.
[5] AgriBoost is a trademark earlier used for Yenomite.
[6] See the first page, second paragraph, line 8 of Dr. Kussow's "First Annual Report."

accompanying the Figure. A high CE is important because it reflects the material's ability to retain potassium and, thereby, provide better plant (turfgrass) growth.[7]

Dr. Wayne Kussow's "Second Annual Report" (Exhibit 2):

This second report of work done Dr. Wayne Kussow also provides a comparison of the performance of different growing soil amendments on turfgrass. Again, two of these soil amendments contained zeolites: Agriboost (*i.e.*, Yenomite) and GSA (another zeolitic material).

Dr. Kussow's report provides the following information:

1. AgriBoost (*i.e.*, Yenomite) had the lowest K_{sat} of all of the materials tested. See Fig. 3 of the report. This means that, of all materials tested including the zeolitic material GSA, Yenomite had the best ability to hold water, making it available to the turfgrass longer. This characteristic indicates that use of Yenomite can lead to a need for less irrigation, resulting in cost savings.

2. Agriboost (*i.e.*, Yenomite) exhibited the environmental advantage of leaching less P than the other soil amendments tested in the study. See table 1 and Fig 5.

Douglas J. Soldat MS Thesis[8] (Exhibit 3):

Douglas J. Soldat's name appears on both of Dr. Kussow's Annual Reports. In the section of his thesis dealing with the environmental merits of the various soil amendments he tested, Mr. Soldat reports that: "AgriBoost [(*i.e.*, Yenomite)] ... greatly reduced the amount of P [phosphorus] leached compared to all other treatments during the first 2 growing seasons (Tables 21a and 21b)."[9] One of these other treatments is the zeolitc material GSA. Mr. Soldat notes (at the top of page 92 of his thesis) that this ability of Yenomite to hold P provides a very substantial advantage against degradation of the surface water of bodies of water situated near the turfgrass,

[7] See the section bridging pages 3 and 4 of Dr. Kussow's"Second Annual Report."
[8] Applicant's Representative apologizes to Examiner Clardy for the poor readability of this document, but they are providing the Examiner with the best copy available to them. They will endeavor to obtain a better copy so as to provide the Examiner with a more readable copy of this document.
[9] See page 91.

thereby reducing the need for costly golf course renovations, and also reducing overall the amount of P leached into the local streams.

Mr. Soldat also notes in the section briding pages 92 and 93 of his thesis that AgriBoost (*i.e.*, Yenomite) is considerably less expensive than is the other zeolitc material, GSA.

The Texas A&M Study (Exhibit 4):

Applicants also submit herewith the results of tests performed at Texas A&M University in a document entitled "Benfits of H2OLD[10] in Growth Media for Ornamental Plant Production." Althought the Micromax (a commercial micronutrient fertilizer) material used in these tests does not contain a zeolite component, these test results show that using Yenomite provides the following advantages:

1. Healthier, better looking plants that reach marketable state and size are obtained earlier.
2. Plant phophorus content is increased. (Phosphorus is necessary for seed germination, photosynthesis, protein formation, and almost all aspects of growth and metabolism in plants.)
3. Plant potassium content is increased. (Potassium is necessary for formation of sugars, starches, carbohydrates, protein synthesis, and cell division in roots and other parts of the plant.)
4. Plant calcium content is increased. (Calcium activates enzymes, is a structural component of cell walls, influences water movement in cells, and is necessary for cell growth and division. Some plants must have calcium to take up nitrogen and other minerals.)
5. Neither the pH nor the electrical conductivity of the medium leachate is affected, which is important for ornamental plants that only tolerate a narrow pH range.
6. Plant iron, boron, manganese, and molybdenum contents are increased.

FIBL "Effects of AgriBoost on the production of transplants (Exhibit 5):

This document reports that AgriBoost (i.e., Yenomite):

[10] H2OLD is Applicant's trademark under which it sells Yenomite.

1. enhanced the growth of cauliflower and tomato plants;
2. enhanced the uptake of several minerals.

As discussed with Examiner Clardy, the prior art did not teach or suggest that using Yenomite in soil would provide such results.

Parham is a review article that pertains to the use of zeolites in general in the depleted soils of developing countries. See the discussion at pg. 109. Parham does not disclose the specific material, Yenomite, as a soil amendment. This publication thus cannot anticipate the present claims.

Dwairi describes a method for the production of a zeolitic material form mining operations in Jordan. While Yenomite is mined in Jordan (as described in the specification) and Dwairi notes that its material has a number of uses, including agricultural uses, he does not report the advantageous agricultural and horticultural benefits one obtains by adding Yenomite to agricultural or horticultural soil, *i.e.*, using Yenomite as a soil amendment. Dwairi says nothing about growing bigger and better vegetables faster, lowering phosphorus leaching into the environment, or improving the efficiency of water use.

Virta is a paper that reports the various properties of zeolites but has nothing to do *per se* with their uses in growing any plants. Ming pertains to using zeolites in lunar agriculture. See, Ming at col. 4, lines 2 and 3. Finally, Goto, as noted by the Examiner, does not relate to Yenomite.

None of the publications relied upon in the rejections teach or suggest that Yenomite would provide the type of results reported in the examples in the specification or in the various additional papers submitted herewith. Accordingly, the rejection of the claims in this

application, under 35 USC 102 and/or 103, over these various publications are all respectfully traversed.

The rejections over 35 USC 101 and 112 have both been obviated by amendment. Claims 1, 2, 5 and 27 have been cancelled and claim 30 has been amended in accordance with the claim language discussed with Examiner Clardy on March 31 as overcoming these grounds of rejection.

Accordingly, it is believed that the application is in condition for allowance.

Respectfully submitted,

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First Annual Report

Jordanian Zeolite 'AgriBoost' as a Golf Course Putting Green Construction Material

Dr. Wayne R. Kussow, Douglas J. Soldat
Department of Soil Science – UW Madison

INTRODUCTION

High-sand-content golf course putting greens provide superior drainage, and increased compaction resistance compared to native soil putting greens. However, high-sand-content greens do not retain nutrients or moisture nearly as well. To compensate for this, organic matter (usually peat moss or compost) is added to the sand. The organic amendments increase the water holding capacity, but do little for the retention of nutrients. Recently, interest has arisen in the use of inorganic amendments in sand-based greens. Two of the most popular inorganic amendments are zeolites and calcined clays. These inorganic amendments have similar physical properties to sand; yet they have the ability to hold substantial amounts of water and nutrients because of their unique chemical properties. The purpose of this study is to quantify the agronomic, economic, and environmental benefits of using a Jordanian zeolite, "AgriBoost," as a golf course putting green construction material.

MATERIALS AND METHODS

During the fall of 2001, a putting green was built to USGA specifications at the O.J. Noer Turfgrass Research and Education Facility in Verona, WI. The green is comprised of twenty 6 ft. by 8 ft. cells consisting of 12 inches of root zone mix overlying a pea gravel blanket with imbedded drain pipe. A plywood grid and plastic sheeting extending the full depth of the root zone physically isolates each cell. The cells are arrayed in 4 rows of 5 cells each. Each row of cells constitutes a replicate of randomly located treatments. The treatments are root zone materials of different compositions. Included are: (1) pure sand; (2) sand + AgriBoost (Jordanian zeolite); (3) sand + GSA ZK406H (a U.S. zeolite); (4) sand + Profile (a porous ceramic material); and (5) sand + peat moss. The ratio of sand: amendment in the mixes is 90:10 (v/v). Each cell was outfitted with a well for insertion of TDR probes at 5 different soil depths for moisture measurement and a low-tension lysimeter for leachate collection (Figure 1). A cover was placed over the green to minimize wind erosion and contamination of the root zone mixes during the winter months.

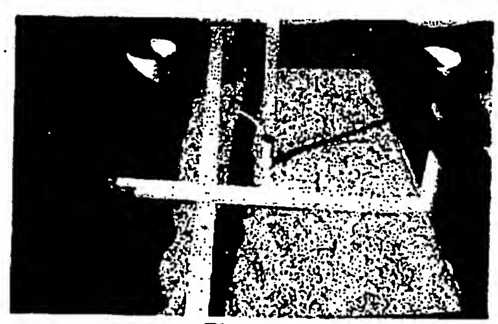

Figure 1

The root zone mixes were prepared by measuring out the volume of sand required, pacing it in a windrow on a paved surface, and spreading over the windrows the proper volume of amendment. These were then blended by making several passes thorough the windrow with a tractor-mounted compost pile mixer (Figure 2).

Figure 2

The putting green will be seeded to L-93 creeping bentgrass (*Agrostis palustris* **Huds**) in mid-May of 2002 or when the soil temperature reaches an acceptable level. The surrounding banks will be sodded with Kentucky bluegrass. Following seeding, a grow in period will take place. Once the grow in period is complete, the green will be placed under an irrigation, mowing, fertilization, and disease control program typical of that of an up-scale Wisconsin golf course.

Plant parameters such as density, quality, green speed, clipping weight, clipping nutrient content, rooting depth, root mass density, disease incidence and severity, and localized dry spot will be measured at varying frequencies. These tests will characterize treatment effects on bentgrass grow in, its subsequent growth, nutrition, and putting green quality. These plant responses will eventually be related to the physical and chemical properties of the root zone materials.

Detailed records will be kept of all construction costs, and any factor that has an influence on the economic and environmental benefits that may accrue from use of the various root zone amendments. Such factors are time to putting green playability, sustained turf quality, fertilizer, water, and pesticide requirements. This information will serve as the basis for treatment cost/benefit analysis.

Relevant physical and chemical properties of the root zone construction materials and mixes are currently being measured in the laboratory. The following section provides a summary of the data collected over the past five months.

Table 2: Water and dilute salt solution pH valu s of th root zone mixes and mix amendments

pH values root zone mix (H_2O)		pH values root zone mix ($CaCl_2$)	
100% Sand	8.94	100% Sand	7.85
90% Sand, 10% AgriBoost	9.03	90% Sand, 10% AgriBoost	7.98
90% Sand, 10% GSA	9.01	90% Sand, 10% GSA	7.60
90% Sand, 10% Peat Moss	8.16	90% Sand, 10% Peat Moss	7.09
90% Sand, 10% Profile	8.68	90% Sand, 10% Profile	7.65
pH values amendments		**pH values amendments**	
100% AgriBoost	8.33	100% AgriBoost	8.03
100% GSA	8.08	100% GSA	7.58
100% Peat Moss	4.28	100% Peat Moss	2.83
100% Profile	6.68	100% Profile	6.05

The AgriBoost mix had the highest pH (Table 2) followed by GSA, Profile, and peat moss respectively; the pH of each root zone mix was dominated by the pH of the sand. This sand like many others used around the U.S. for putting green construction, contains a yet to be determined amount of carbonates.

Cation Exchange Capacity:

Compared to the minerals commonly found in soils, zeolites have a unique property. Due to the nature of their crystalline structures, many of the negative charged sites in zeolites can be accessed by cations such as NH_4^+ and K^+ that have small hydrated radii (< 5A.), but not by large cations such as Ca^{2+} and Mg^{2+} whose hydrated radii are 9.6A and 10.8A respectively. This can be a very important distinction from the perspective of N and K management in sand based putting greens. The NH_4^+ and K^+ bonded to the sterically restricted sites in zeolite are not subject to displacement by Ca^{2+} or Mg^{2+} and will therefore, suffer much lower leaching loss as compared to root zone mixes that do not contain zeolite.

To verify the existence and magnitude of the preferential bonding of NH_4^+ and K^+, the cation exchange capacities of the root zone mixes and amendments were determined via Ca^{2+} saturation/Mg^{2+} displacement (Figure 3) and NH_4^+ saturation/K^+ displacement methods (Figure 4).

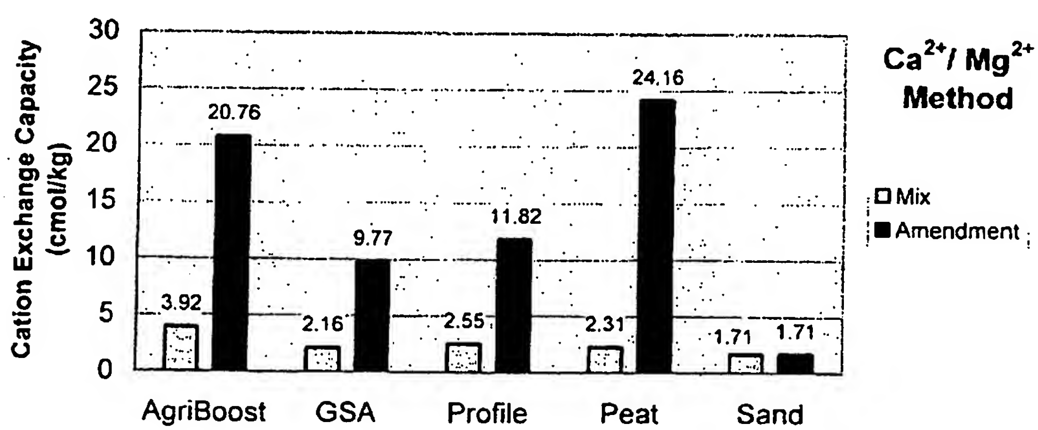

Figure 3

RESULTS AND DISCUSSION

Particle Size Distribution:

The first objective of the lab analyses was to verify that the field blended root zone mixes were as uniform as can be expected and are the intended 90:10 (v:v) blends. To do this, laboratory root zone mixes were carefully prepared in small batches using a twin shell blender. The carefully blended lab mixes were compared to the field mixes.

The particle size distributions of the laboratory and field mixes were very similar (Table 1) suggesting that the compost pile mixer used was an effective tool for creating uniform root zone mixes. There was some concern that AgriBoost, which has a wide range of particle sizes, would not yield a mix that meets USGA specifications. While the AgriBoost amended mix did have higher percentages of very fine sand and silt + clay than in the other mixes, the mix does meet USGA standards of <10% fine gravel and very coarse sand, >60% coarse and medium sand, and < 10% very fine sand + silt and clay.

Table 1: Particle size distribution of root zone mixes prepared in the lab and in the field

Lab Samples - Root Zone Mixes

Name	Particle diameter	AgriBoost	Profile	Peat Moss	GSA	Sand
Fine Gravel	2.0 - 3.4 mm	0.82%	0.72%	1.25%	0.88%	0.80%
Very Coarse Sand	1.0 - 2.0 mm	7.06%	5.62%	5.86%	7.17%	6.05%
Coarse Sand	0.5 - 1.0 mm	21.75%	22.65%	21.63%	25.07%	21.33%
Medium Sand	0.25 - 0.50 mm	40.28%	41.49%	42.55%	39.84%	42.49%
Fine Sand	0.15 - 0.25 mm	26.90%	26.73%	26.38%	24.90%	26.73%
Very Fine Sand	0.05 - 0.15 mm	2.18%	2.03%	1.70%	1.62%	1.75%
Silt and Clay	less than 0.05	1.01%	0.76%	0.62%	0.52%	0.85%

Field Samples - Root Zone Mixes

Name	Particle diameter	AgriBoost	Profile	Peat Moss	GSA	Sand
Fine Gravel	2.0 - 3.4 mm	0.56%	0.48%	1.04%	0.46%	0.29%
Very Coarse Sand	1.0 - 2.0 mm	6.37%	5.20%	5.31%	7.02%	5.76%
Coarse Sand	0.5 - 1.0 mm	22.42%	24.17%	23.34%	26.52%	22.90%
Medium Sand	0.25 - 0.50 mm	42.77%	44.11%	45.13%	42.56%	44.00%
Fine Sand	0.15 - 0.25 mm	24.94%	24.09%	23.54%	21.79%	25.11%
Very Fine Sand	0.05 - 0.15 mm	1.72%	1.27%	1.12%	1.00%	1.30%
Silt and Clay	less than 0.05	1.22%	0.67%	0.52%	0.66%	0.65%

pH values:

The $CaCl_2$ and H_2O soil solution pH values of the root zone mixes and the amendments are listed in Table 2. The pH was run in a 0.01 M $CaCl_2$ solution because this more closely approximates field pH of a fertilized putting green.

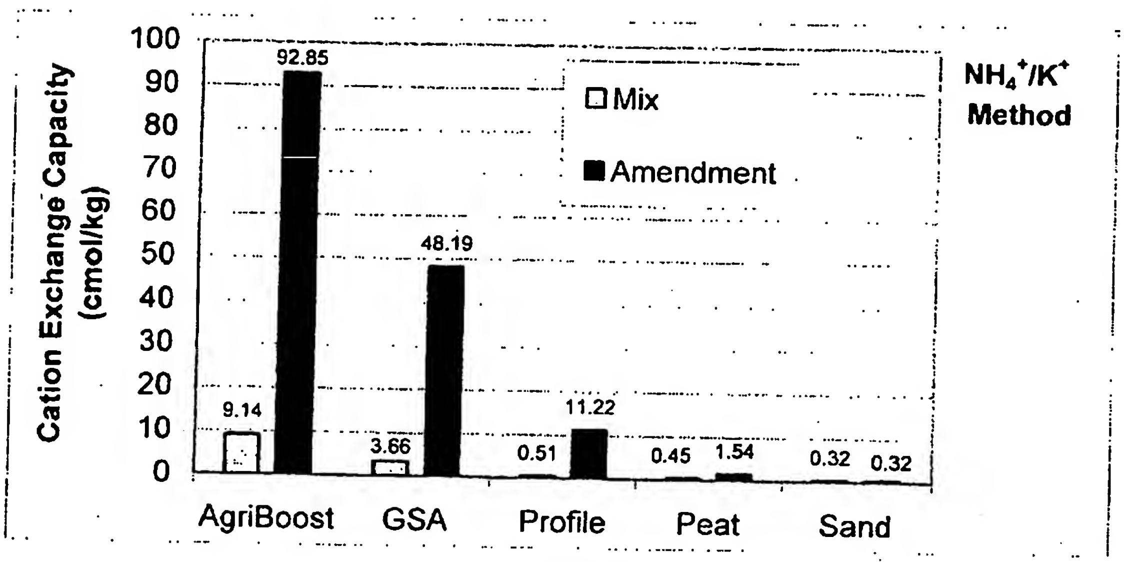

Figure 4

One thing that is important to note, is that the cation exchange capacity measurements are taken on a weight basis while the root zone mixes are created strictly by volume measurements. Therefore, the peat moss appears to have a relatively high cation exchange capacity as an amendment, but loses much of that benefit when incorporated into a 90:10 (v:v) root zone mix. Peat moss has a much smaller weight to volume ratio than any of the other amendments used in this study. Another important property of peat moss is demonstrated by these two experiments. Peat moss is capable of retaining relatively large amounts of divalent cations, but retains very few monovalent cations such as NH_4^+ and K^+ on its exchange sites. We see this when the cation exchange capacity of the peat moss changes from 24.16 cmol kg^{-1} when divalent cations are used to 1.54 cmol kg^{-1} when monovalent cations are used.

When the ammonium/potassium method was used, the estimated cation exchange capacity of each zeolite (AgriBoost and GSA ZK406H) increased roughly five times from that obtained using the calcium/magnesium method. The other inorganic amendment used in this study, Profile, showed almost no change in cation exchange capacity from one method to the next indicating that all negatively charged sites in the product are equally accessed by monovalent and divalent cations. The pore spaces in the zeolite act as an ionic sieve, letting the smaller ions (in this case ammonium and potassium) pass, while denying the larger ions access to many of its exchange sites. It should be noted that although AgriBoost and GSA ZK406H are both zeolites, AgriBoost demonstrated a CEC of almost twice that of GSA.

Moisture Release Data:

Soil cores were prepared for the moisture release measurements by compacting them to the degree of a severely compacted putting green. While this is the standard laboratory method used for evaluating putting green root zone mixes, it represents a worst-case scenario and most likely does not represent the field conditions that would be found in a new putting green.

Obtaining moisture release data is a very lengthy process. Approximately six weeks are required to obtain one moisture release curve. Fortunately, we have the equipment to measure up to ten curves simultaneously. The data included in this report are incomplete (Figure 5). Data is

RESEARCH PROPOSAL

Title: Jordanian Zeolite as a Golf Putting Green Construction Material

Purpose: To demonstrate that Jordanian zeolite, with its unique chemical and physical properties, can be employed to construct golf putting greens that excel in terms of turfgrass establishment, subsequent putting green quality, and ease and cost of maintenance.

Principal Investigator: Dr. Wayne R. Kussow
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Protocol: For the purposes of this research a golf putting green will be constructed according to USGA standards at the University of Wisconsin O. J. Noer Turfgrass Research and Education Facility. The green will be comprised of twenty 6 ft x 8 ft cells consisting of 12 inches of root zone mix overlying a coarse sand layer and a pea gravel blanket with imbedded drain pipe. Each cell will be physically isolated with plastic sheeting extending the full depth of the root zone mix. The cells will be arrayed in 4 rows of 5 cells each. Each row of cells will constitute a replicate of randomly located treatments. The treatments will be root zone materials of different compositions and will be: (1) pure sand; (2) sand + Jordanian zeolite; (3) sand + Zeopro (a U.S. zeolite); (4) sand + Profile (a porous ceramic material); and (5) sand + peat moss. The ratio of sand: amendment in the mixes will 85:15 (v/v). Once constructed, each cell will be outfitted with a well for insertion of TDR probes at 5 different soil depths for moisture measurement and with a low tension lysimeter for leachate collection.

After construction of the green and the surrounding banks sodded, the green will be outfitted with an automated irrigation system and seeded to 'L - 93' creeping bentgrass (*Agrostis palustris* **Huds**). The target date for seeding will be early August 2001. The grow-in period will extend to June 2002, during which time the green will be subjected to a typical grow-in fertilization program consisting of light, frequent N applications to force rapid growth and monthly applications of P and K. After June 2002 the green will be placed under an irrigation, mowing, fertilization, and disease control program typical of that of an up-scale Wisconsin golf course. The study will extent through the 2003 growing season.

All root zone construction materials and mixes will have their relevant physical and chemical properties measured. Commencing in the fall of 2001 the tests listed below will be performed for all cells (treatments and replicates) according to the schedule shown. The purpose of these tests is to establish treatment differences and to track any changes that may occur over time.

Root zone mix characteristic	Frequency of determination

Bulk density	Spring and fall
Infiltration rate	Spring and fall
Hydraulic conductivity	Spring and fall
Cation exchange capacity	Spring and fall
Exchangeable cations	Spring and fall
Routine soil tests (pH, P and K)	Spring and fall
Volumetric soil moisture	Bi-monthly
Leachate volume and composition	Monthly

Plant parameters to be measured and their frequency are listed below. These tests characterize treatment effects on turfgrass growth, nutrition, and putting green quality. These plant responses will eventually be related to the physical and chemical properties of the root zone materials.

Plant parameter	Frequency of measurement
Stand density	Daily during the early phase of grow-in; Monthly thereafter.
Visual quality ratings	Monthly
Green speed	Monthly
Clipping weight	Bi-monthly
Clipping nutrient content	Bi-monthly
Rooting depth	Spring, summer, fall
Root mass density	Spring, summer, fall
Disease incidence and severity	When disease occurs
Localized dry spot	When it occurs

Economic analysis: Detailed records will be kept of all construction costs, and any factor that has an influence on the benefits that may accrue from use of the various root zone amendments. Such factors are time to putting green playability, sustained turf quality, and fertilizer and water requirements. This information will serve as the basis for treatment cost/benefit analysis.

Reporting: An annual written report of research results and activities will be submitted to the sponsor in January of each project year. A final report in the form of a graduate student thesis will be submitted by June 2004. One or more manuscripts will be prepared and submitted to a peer reviewed technical journal for publication. Oral reports will be given at state and national turf conferences when the opportunity arises.

Proposed Budget:

Line item	Year 2001	Year 2002	Year 2003
Site excavation, grading	$ 1,000	-	-
Drainage system	500	-	-
Irrigation system	500	-	-
Root zone mix blending and transport	4,500	-	-
Construction materials	2,000	-	-
Labor (1,200 hrs @ $9)	10,800	-	-
Research Assistant (50% time)			
Stipend		$17,168	$18,026
Fringe benefits	-	2,576	2,884
Tuition remission	-	4,292	4,506
Supplies and materials			
Field	-	300	350
Laboratory	-	1,200	1,250
Equipment maintenance	-	500	600
Analytical services	-	2,400	2,600
Sub-totals:	$15,300	$28,426	$30,216
Indirect costs(45.5%)	6,962	12,938	13,748
Totals:	$22,262	$41,374	$43,964

Grand Total: $107,600

SECOND ANNUAL REPORT

Jordanian Zeolite 'AgriBoost' as a Golf Course Putting Green Construction Material

Dr. Wayne R. Kussow, Douglas J. Soldat
Department of Soil Science – University of Wisconsin – Madison

Data included in first annual report (01/2002):

- particle size distribution of root zone mixes and materials
- pH of root zone mixes and materials
- cation exchange capacity of root zone mixes and materials
- moisture release curve of root zone mixes (incomplete)

Data included in second annual report (02/2003):

<u>Laboratory Results</u>
- moisture release curves
- saturated hydraulic conductivity
- carbonate content of sand and amendments
- potassium sorption capacity
- phosphorus adsorption and desorption

<u>Field Observations</u>
- leachate analysis
- soil test P and K
- root mass density
- infiltration rates
- clipping weights
- clipping N, P, and K content
- turf color, quality, and density/uniformity ratings

<u>Tables and Figures</u>

LABORATORY

Moisture Release Curves

The first annual report did not include all of the moisture release data, as analysis was not yet complete. Figure 1 shows the final moisture release curves for the individual root zone mixes. The data show that peat moss holds more water than the other treatments at low tension. The other treatments appear to be very similar to each other in regard to moisture release. Because the sand used in this experiment contains 26.7% fine sand (0.15 - 0.25 mm) and 63.8% medium and coarse sand (0.25 – 1.00 mm), the root zone mixes are able to retain more water than a root zone mix containing more medium to coarse sand. This, coupled with the 90:10 sand: amendment ratio, decreases our ability to resolve moisture release treatment differences among the inorganic amendments.

For rapid turfgrass establishment, reduced occurrence of localized dry spot, and overall enhanced turfgrass quality, a root zone mix should have a volumetric water content of 15% or more at 30 cm tension (H_2O). All of our root zone mixes met this criterion (Fig. 1), and demonstrated the aforementioned benefits in the field during the growing season. Figure 2 shows the percent water by volume held by each root zone mix at 25 – 60 cm tension (H_2O). This range estimates plant available water. Surprisingly, none of the inorganic amendments increased the amount of plant available water in their respective root zone mixes compared to sand alone.

Saturated Hydraulic Conductivity

Saturated hydraulic conductivity (K_{sat}) is a measure of the rate which water moves through a compacted, saturated soil core. For this study, the procedure for measuring K_{sat} employed by all USGA certified laboratories was followed. The USGA recommends K_{sat} rates of 6 – 12 in/hr for 'normal' conditions. All of the root zone mixes used in this study exceed this range. Besides measuring the K_{sat} of heavily compacted root zone mixes, the K_{sat} of the root zone

mixes after light compaction was also measured. This compaction level was intended to represent a newly constructed putting green. The data show that AgriBoost has the lowest K_{sat} at both compaction levels (Fig. 3); meaning water drains more slowly and is available to the turfgrass for a longer period of time following an irrigation event. This could lead to a reduction in irrigation frequency and subsequent cost savings. A greenhouse study is underway to characterize treatment effects on drainage (pg. 7).

Carbonate Content of Sand and Inorganic Amendments

In Wisconsin and much of the mid-west, the available sand contains variable amounts of carbonates. The sand used for this project has a calcium carbonate equivalent (CCE) of 4.3%. When large amounts of carbonates are present in a root zone mix, they control the pH and adsorb significant amounts of phosphorus (P). Laboratory analysis revealed that AgriBoost contains nearly 4% CCE. This explains the high pH of the AgriBoost treatment and the relatively low amount of P found in the leachate throughout the 2002 growing season (Table 1). Using AgriBoost over the other amendments in this study for putting green construction provides potential environmental and economic benefits due to the relatively low amount of P leaching associated with the AgriBoost treatment.

Potassium Sorption Capacity

The sand used for constructing sand-matrix putting greens typically has a negligible cation exchange capacity (CEC). The CEC of the sand used in this study is 0.3 cmol/kg. Potassium (K) is a cation required by turfgrass in relatively large quantities, typically accounting for 2 – 3 % of the dried tissue weight. Root zones mixes without adequate CEC are unable to retain sufficient amounts of K for an entire growing season. Much of the applied K leaches out of the root zone after a large K fertilizer application. In order to prevent K deficiencies from occurring in turfgrass grown on a sand-matrix root zone, several small applications of K are

required throughout the growing season. These additional applications are labor intensive and therefore costly. The CEC of the zeolite treatments suggest that those treatments might be able to retain sufficient quantities of K for turfgrass growth for an entire season. To verify this, K sorption curves were developed to characterize each root zone mix's ability to retain K. There were large differences in K retention between the zeolite treatments and the remaining treatments (Fig. 4). Also evident were differences in K retention between the two zeolite treatments. The slopes of the individual sorption curves indicate that the AgriBoost root zone mix has a greater affinity for K than does the GSA zeolite root zone mix. This implies that in the field there will be substantial differences in K fertilizer use efficiency between the treatments. Monitoring these differences will be the focus of next season's work.

Phosphorus Adsorption and Desorption of Root Zone Mixes

Phosphorus (P) is another nutrient used in relatively large quantities by turfgrass, typically accounting for around 0.5 % of the dried tissue weight. An adequate supply of P is of special importance during the establishment phase. In sand-matrix putting greens, adsorbed P controls solution P and, in calcareous root zone mixes, is determined primarily by the amount of carbonates present. The high carbonate content of the AgriBoost root zone mix explains why it adsorbs more P than the other treatments (Fig. 5). The fact that AgriBoost adsorbs more P does not necessarily mean that the AgriBoost treatment will contain more plant available P than any other treatment. One measure of plant available P is soil test P. There were no differences in soil test P that could be directly related to the P adsorption of the root zone mixes (Table 2).

Figure 6 shows the relationship between the total amounts of P found in the leachate for each treatment and the relative amounts of P that were desorbed in a laboratory experiment using iron oxide impregnated filter paper. The results suggest that P leaching in the field can be estimated by the amount of P desorbed by the filter paper.

FIELD OBSERVATIONS

The experimental putting green was seeded to 'L-93' creeping bentgrass on May 15, 2002. The surrounding banks were sodded with Kentucky bluegrass. The green was subjected to a typical grow-in program consisting of light, frequent applications of nitrogen. The fertilization schedule is listed in Table 3. Plots were fertilized individually on the basis of achieving a uniform color rating among the treatments. This resulted in the withholding of one ¼ lb N/M application on both zeolite treatments. The color differences that led to this decision to withhold the fertilizer are shown in Fig. 7. No statistical differences in color, quality, or clipping weights were noted between the treatments when averaged over the 2002 growing season. The data presented in Table 4 summarizes the treatment effects on clipping weight and clipping N, P, and K content. Turfgrass color, quality, and density ratings are listed in Table 5. The AgriBoost and peat moss treatments had significantly greater density/uniformity ratings than the other treatments when averaged over the 2002 growing season.

Table 2 lists treatment effects on soil test P & K, root mass density, and infiltration rate. When soil samples were pulled on 9/21/02, the AgriBoost treatment had roughly 5 times the amount of soil test K than the other treatments. The CEC of the root zone mixes correlates with the amount of soil test K, however, the ratio of K: CEC is very different for the two zeolite treatments. The AgriBoost treatment has a higher K: CEC ratio than the GSA zeolite treatment, suggesting that AgriBoost has a greater affinity for K than does GSA. This conclusion was also made earlier in the laboratory after analyzing the K sorption data.

Table 2 shows the statistical differences in root mass density between the treatments. The root mass density value for peat moss may be artificially low due to the difficulty of separating the roots from the peat moss. This was not an issue with the inorganic amendments. A laboratory leaching study initiated last year revealed that AgriBoost contains and leaches a large amount of sodium. High sodium concentrations are known to decrease rooting as well as suppress K uptake. This may be the reason for the relatively low root mass density value of the AgriBoost treatment. However, as the sodium is gradually leached out of the root zone mix over time, the root mass density may begin to increase for the AgriBoost treatment. Treatment effects on root mass density will continue to be tracked during the upcoming season.

Infiltration rates are reported in Table 2. Peat moss had the lowest infiltration rate, while Profile had the greatest. All of the inorganic amendments had greater infiltration rates than sand. AgriBoost had the lowest infiltration rate of the inorganic amendments, supporting the results for the laboratory K_{sat} experiment.

Leachate Analysis

Leachate was collected using low-tension lysimeters installed beneath the root zone mixes in each of the plots. The leachate was analyzed for nitrate – N (NO_3^-), ammonium – N (NH_4^+), Potassium (K^+), and orthophosphate (P). Results for the 2002 growing season are shown in Fig. 8 – 11.

Figure 8 shows the amount of N leached through the root zone mixes during the grow-in. The grow-in period was defined as the time from seeding until 100% cover was reached by the last plot. This occurred on August 19, 2002. The GSA zeolite treatment significantly reduced nitrate and total N leaching compared to the peat moss treatment. The amount of NO_3^- - N found in the GSA treatment's leachate during grow-in was not very different from the amount of NO_3^- - N found in that treatment after the grow-in was complete. This did not hold true for any other treatment. The data suggest that GSA zeolite can significantly reduce the amount of $NO3^-$ - N leaching during putting green grow-in when used in place of Canadian sphagnum peat moss. This may be of high value in an environmentally sensitive area.

Figure 9 shows the amount of N leaching through the root zone mixes after grow-in was complete and up to the end of the growing season (mid-November). There was a dramatic drop in N leaching for all treatments after the grow-in had taken place. This corresponds with the development of the turf's fibrous root system. After grow-in, no significant differences in total N leaching between any of the treatments existed.

Figure 10 shows the total P content of the leachate for the 2002 growing season. <u>The Profile treatment consistently leached significantly more P than the other treatments. Solution P concentrations from this treatment typically exceeded 1 ppm, a concentration that is potentially hazardous to the environment.</u> There were no significant differences in the amount of P leached between the remaining treatments.

Total K content of the leachate for the 2002 growing season is shown in Fig. 11. This data does not correspond to the laboratory data. Next season special emphasis will be placed on K retention and movement within the root zone mixes in order to better our understanding of the treatment effects on K.

CURRENT RESEARCH AND FUTURE PLANS

A greenhouse experiment is underway, the primary purpose being to establish treatment effects on drainage rate. To simulate a USGA putting green, eight inch diameter cylinders were filled with 12 inches of root zone mix overlaying 4 inches of pea gravel. Each cylinder contains 6 evenly spaced slots for the insertion of soil moisture probes and an outlet to collect leachate. After the turfgrass is established, irrigation events will be simulated and the moisture probes will record the movement of the water. Slower drainage rates allow for less frequent irrigation, thereby leading to differences in water usage. Treatment effects on irrigation requirements will be a main focus in the field during the 2003 growing season. The irrigation system for the field plots will be re-designed such that the plots can be watered individually; allowing the differences in irrigation requirements to be quantified. The data collection schedule outlined in the original project proposal for the upcoming growing season will be employed. Potassium retention and movement through each root zone mix will be intensively monitored. Treatment effects on potassium retention are expected to be found, and economic values will be assigned to those effects.

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FIGURES AND TABLES

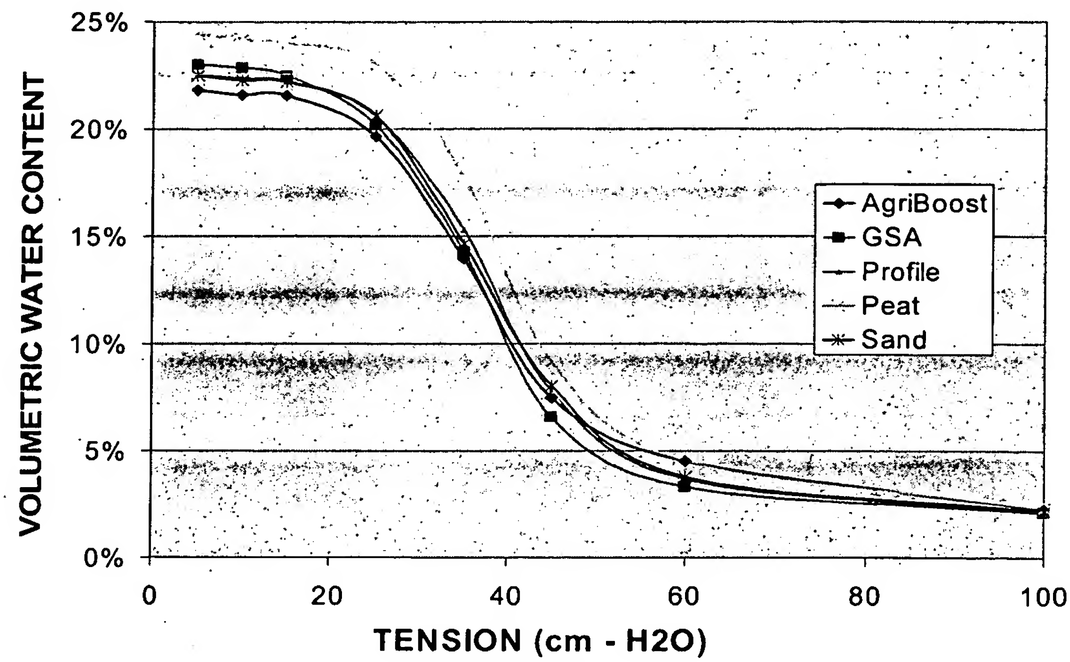

FIGURE 1

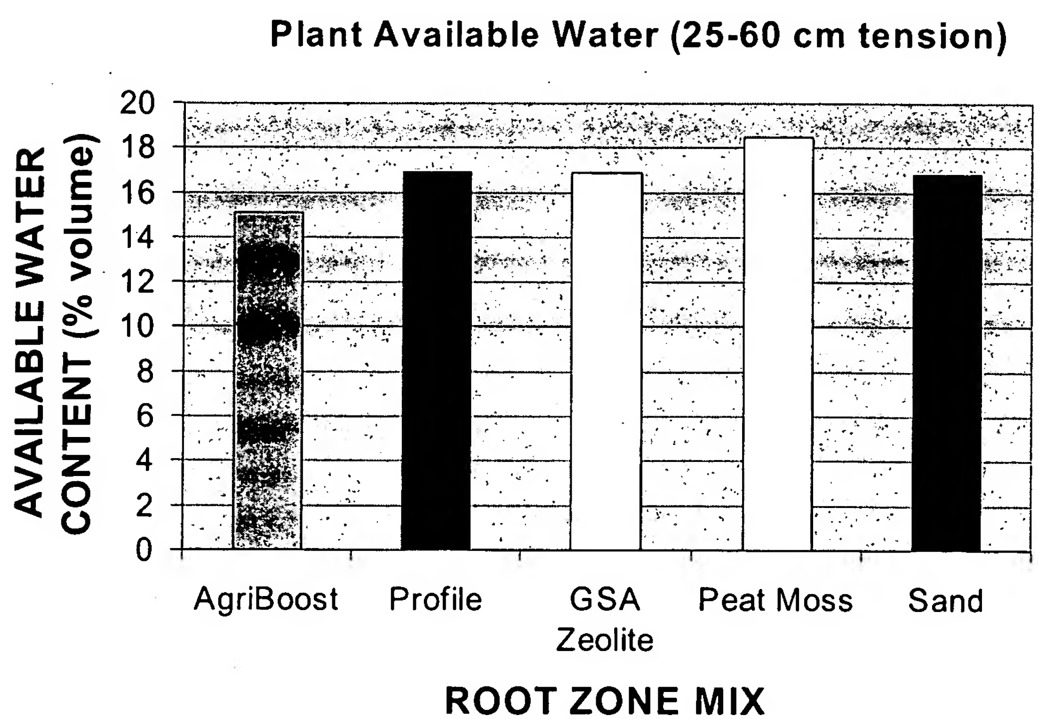

FIGURE 2

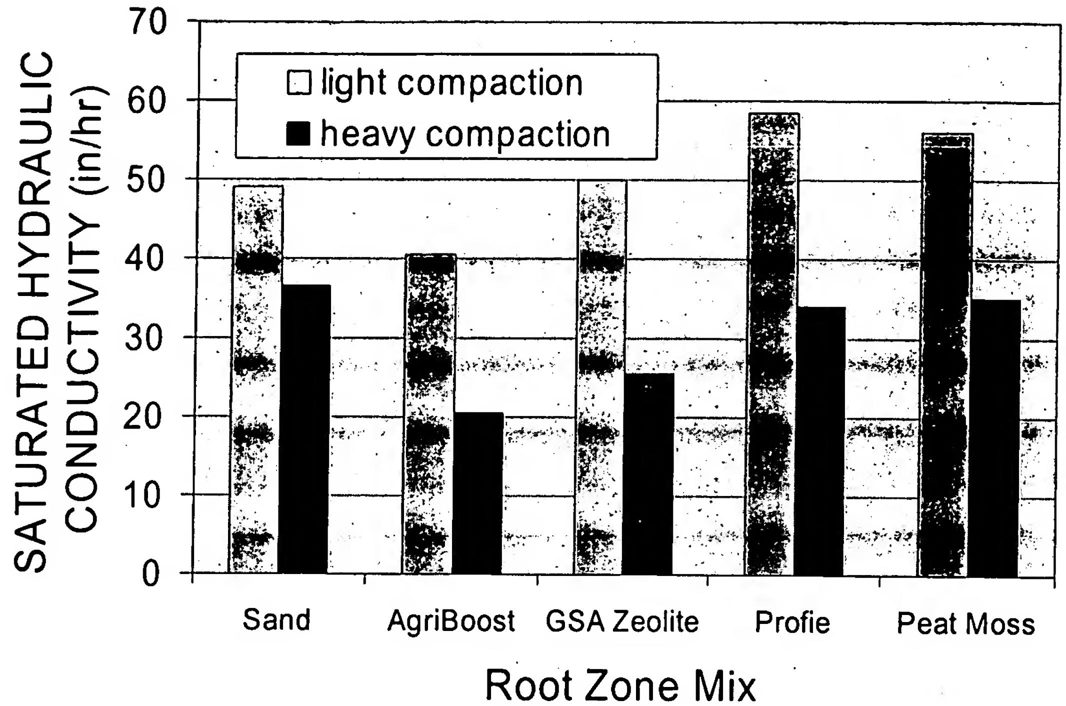

FIGURE 3

Table 1. Effect of %CCE of amendments on pH and P leaching.

Amendment	pH of root zone mix	Leachate P (sum for 2002 season)	CCE of amendment
	In $CaCl_2$	kg/ha	%
AgriBoost	7.98	1.31 b*	3.94
Profile	7.65	14.63 a	0.66
GSA Zeolite	7.60	3.23 b	0.52
Peat Moss	7.09	4.65 b	-----
Pure Sand	7.85	4.07 b	4.34

*similar letters within columns are not statistically different at 0.05 significance level

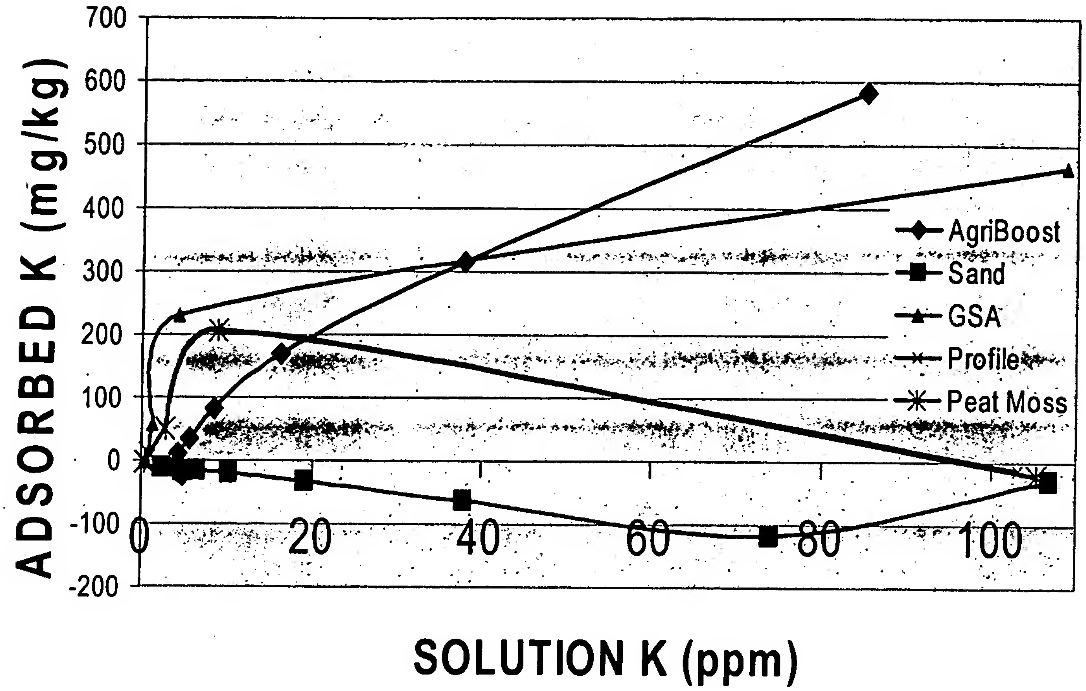

FIGURE 4

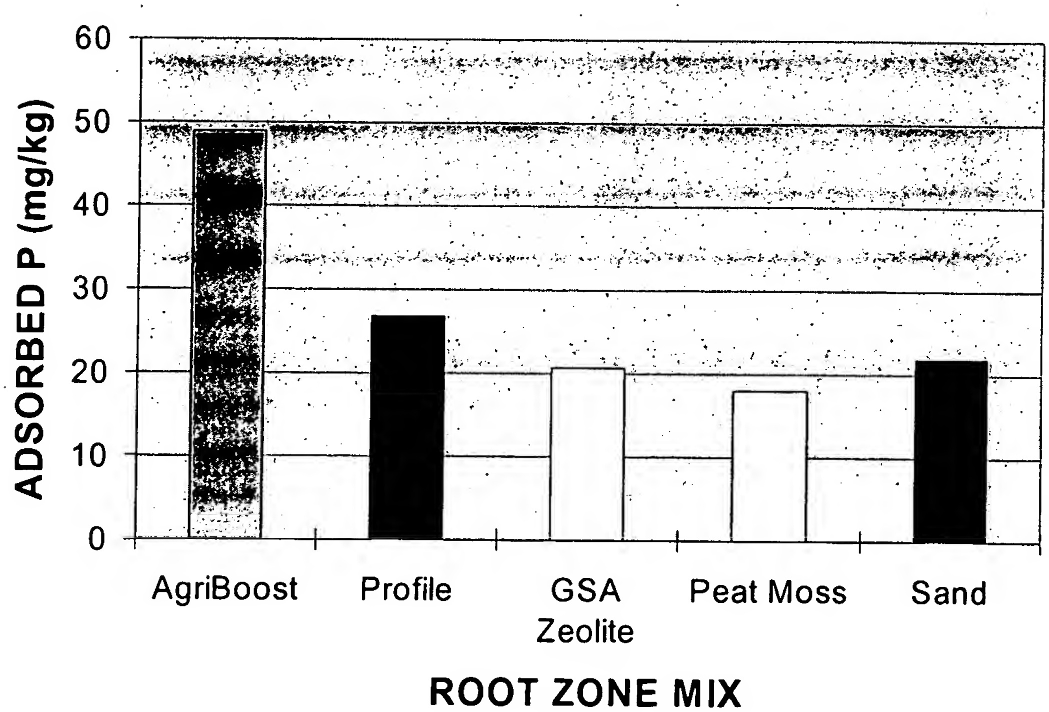

FIGURE 5

Table 2. Treatment effects on soil test P & K, root mass density, and infiltration rates.

Root Zone Mix	Soil Test K	Soil Test P	Root Mass Density	Infiltration Rate
	--------mg/kg--------		mg	in/hr
AgriBoost	100.9	16.6	62.3 c	33.6
Profile	16.1	15.1	89.5 a	38.6
GSA	22.0	17.8	79.3 b	34.5
Peat Moss	12.8	13.9	45.8 d	22.2
Sand	12.9	17.1	84.0 ab	32.4

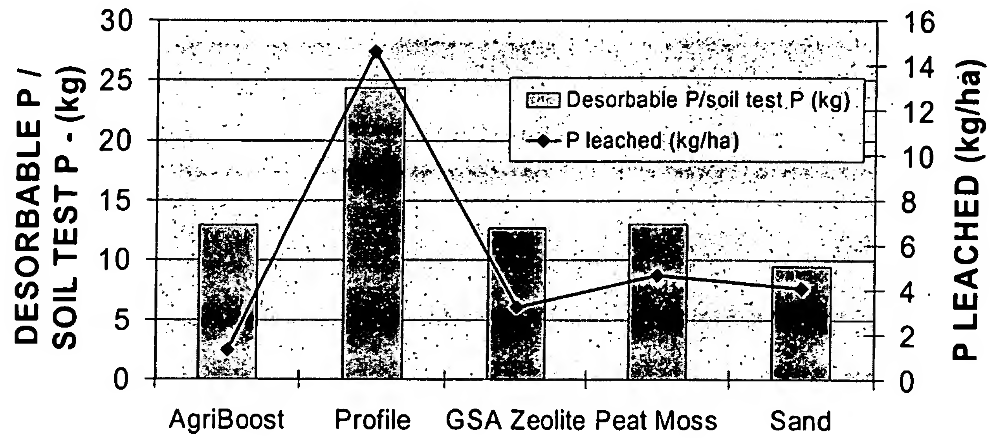

FIGURE 6

Table 3. Fertilizer applications in 2002.

Application Date	Fertilizer Type	Rate
		lb. N – K_2O – P_2O_5 / M
5/15/02	14-28-12	0.5 - 1.0 - 0.4
5/30/02*	46-0-0	0.25 – 0 - 0
6/10/02	46-0-0	0.30 – 0 - 0
6/26/02	14-28-12	0.5 - 1.0 - 0.5
7/8/02	46-0-0	0.5 - 0 - 0
7/25/02	46-0-0	0.8 – 0 - 0
8/2/02	18-3-18	0.5 - 0.1 - 0.5
9/3/02	14-28-12	0.5 - 1.0 - 0.4
10/26/02	0-0-50	0 – 0 - 1.6
10/27/02	24-2-12	0.4 - 0.03 - 0.2

*Not applied either zeolite treatment

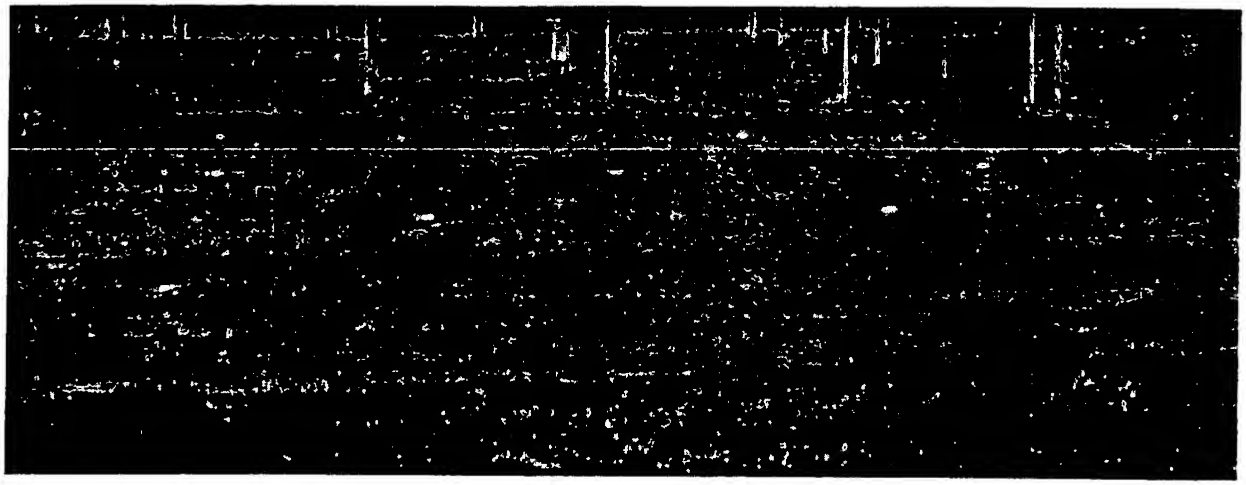

FIGURE 7

Table 4. 2002 averages of treatment effects on clipping weight, clipping N, P and K content.

Root Zone Mix	Total N Applied	Clipping Weights	Clipping N Content	Clipping P Content	Clipping K Content
	lb/M/yr	g	----------------------	%	----------------------
AgriBoost	4.9	3.69 a	3.56 b	0.413 ab	2.42 ab
Profile	5.1	4.09 a	3.49 b	0.393 b	2.30 b
GSA	4.9	3.64 a	3.60 ab	0.438 ab	2.50 a
Peat Moss	5.1	3.81 a	3.59 ab	0.463 a	2.31 b
Sand	6.4*	4.35 a	3.73 a	0.440 ab	2.50 a

*1.3 lb N/M provided by a product named 'Grow-in' used during establishment for increasing moisture retention of the sand treatment

Table 5. Treatment effects on turfgrass color, quality, and density/uniformity.

Root Zone Mix	Color Ratings	Quality Ratings	Density/ Uniformity Ratings
	1-9	1-9	1-9
AgriBoost	7.04 a	7.90 a	7.03 a
Profile	6.97 a	7.85 a	6.60 b
GSA	6.97 a	7.84 a	6.71 b
Peat Moss	6.97 a	7.86 a	7.01 a
Sand	7.02 a	7.78 a	6.13 b

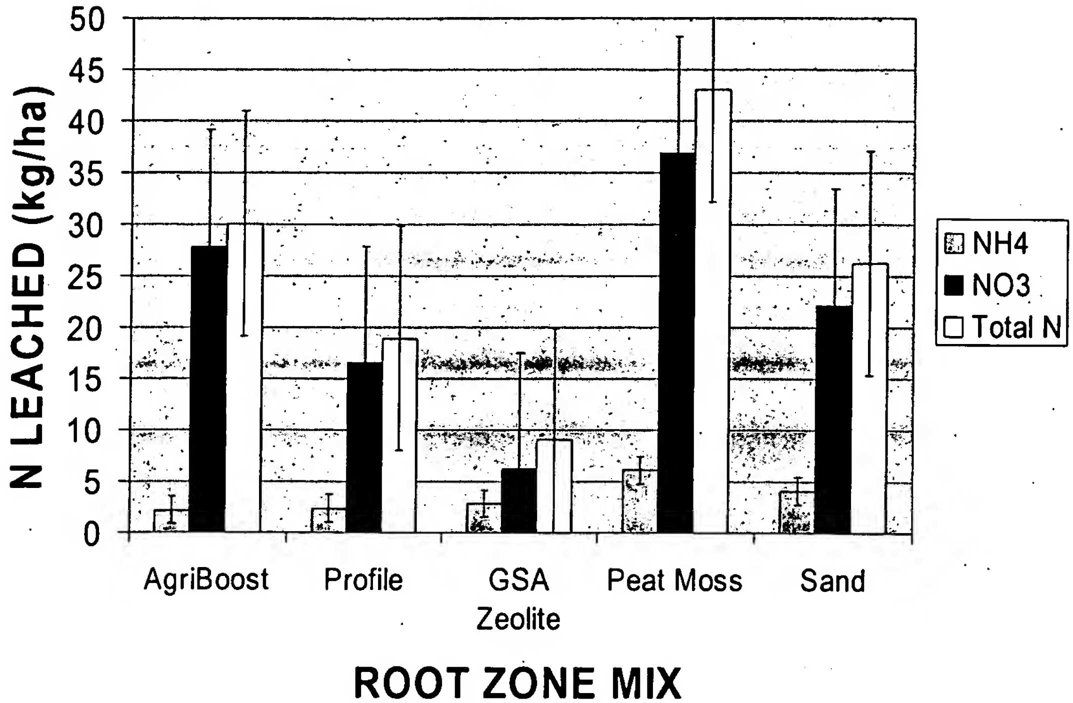

FIGURE 8

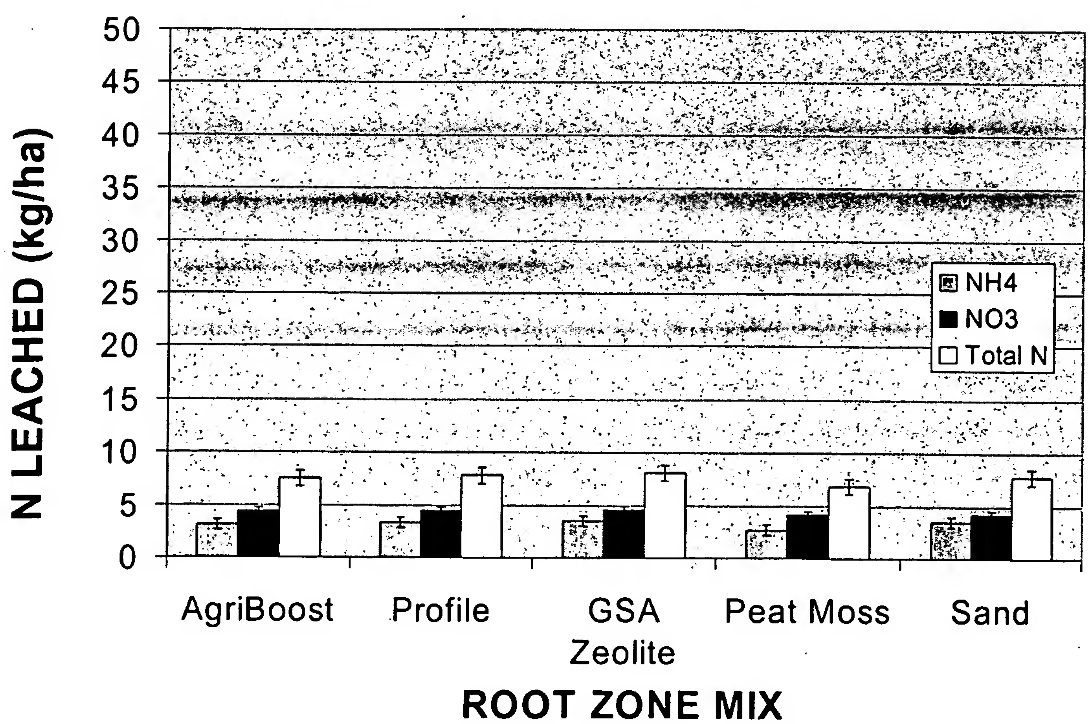

FIGURE 9

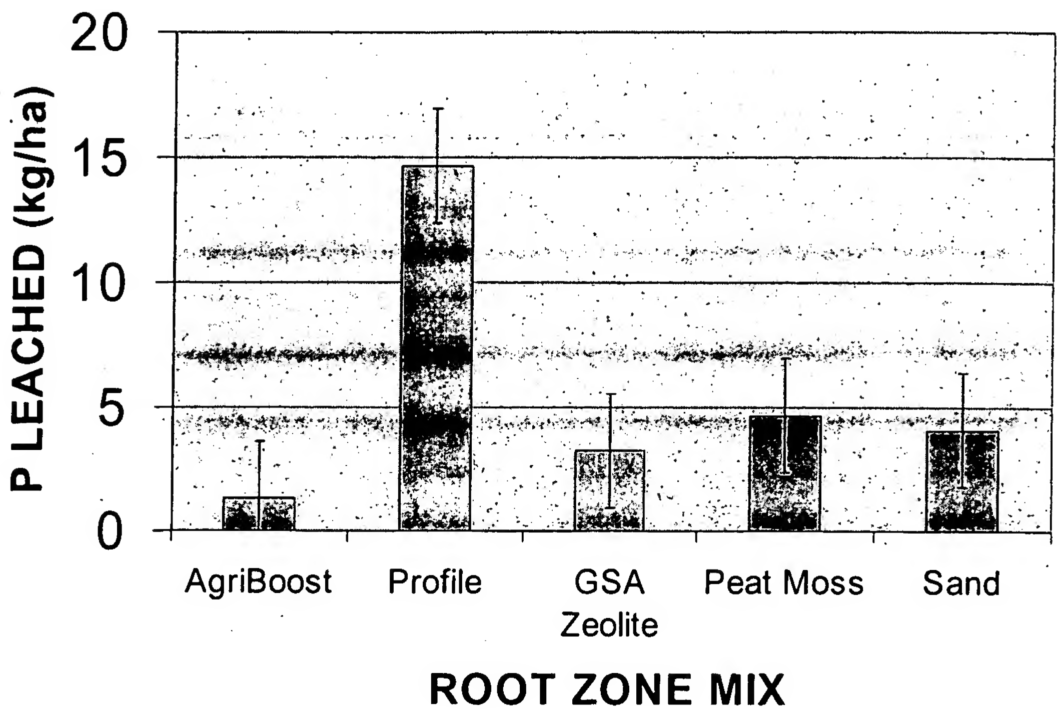

FIGURE 10

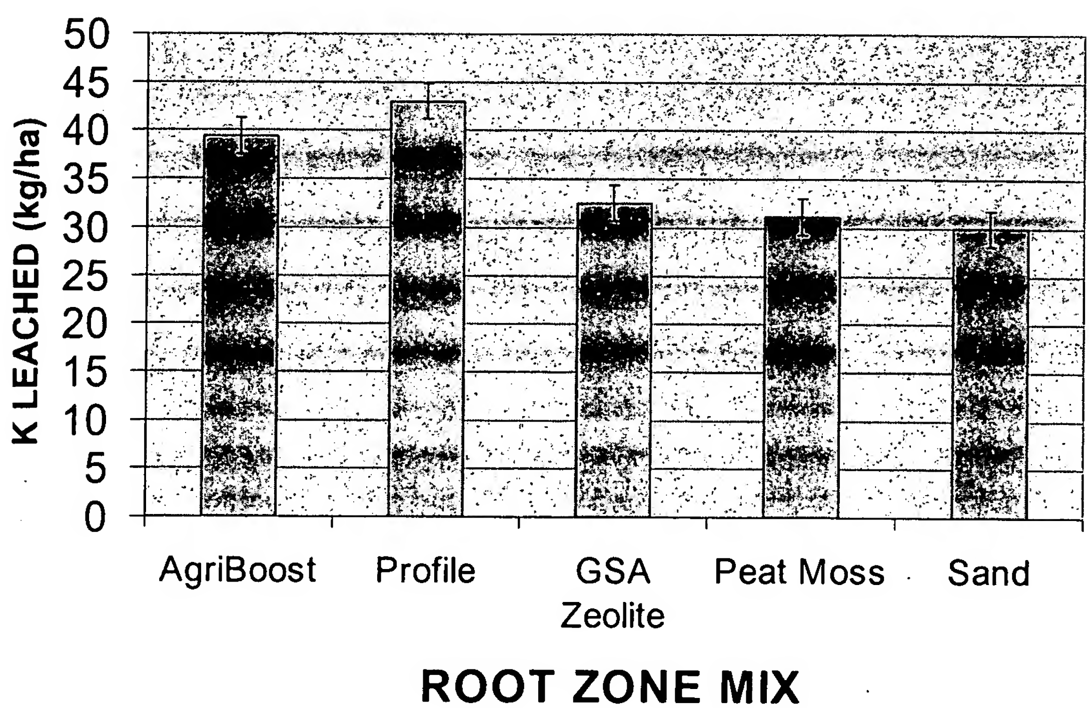

FIGURE 11

INORGANIC AMENDMENTS AS PUTTING GREEN CONSTRUCTION MATERIALS

by

Douglas J. Soldat

A thesis submitted in partial fulfillment of the

requirements for a degree of

Master of Science

(Soil Science)

at the

UNIVERSITY OF WISCONSIN – MADISON

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SUMMARY AND CONCLUSIONS

The purpose of this research project was to assess the agronomic, environmental, and economic advantages and disadvantages of using inorganic amendments in place of sphagnum peat or no amendment in sand-matrix golf putting green root zone mixes. Data collected from a 15-month field trial, a greenhouse investigation of water retention and drainage rates, and numerous laboratory measurements support the following conclusions.

Agronomic Merits of the Root Zone Amendments

Over the course of this study, several agronomic responses to the various root zone mixes were recorded. They included turfgrass quality, color, and establishment rate. Rapid bentgrass establishment is a desirable characteristic with economic implications. During the establishment period, The AgriBoost® and peat treatments improved bentgrass establishment compared to all other treatments while the GSA ZK406H and Profile® treatments significantly improved turfgrass establishment compared to the pure sand treatment (Table 14). Once the putting greens are in play, the ability to sustain a high quality playing surface is of paramount importance. The AgriBoost® treatment out-performed the Profile® treatment in terms of turfgrass quality over the duration of the study. The peat treatment had a significantly better mean color rating than the Profile® treatment in 2002 (Table 26). No single root zone mix characteristic could account for these differences.

Although relatively large differences in root mass density were found among treatments, those differences were not manifested in visual ratings. The GSA ZK406H, Profile®, and pure sand treatments had significantly greater root mass density than the AgriBoost® and peat treatments during the 2002 and 2003 seasons (Table A-12).

In summary, greens amended with AgriBoost® or Canadian sphagnum peat provided agronomic advantages over unamended greens and those amended with GSA ZK406H and Profile®.

Environmental Merits of the Root Zone Amendments

Environmental merits are more difficult to quantify in comparison to agronomic and economic merits. The primary environmental parameter measured in this study was nutrient leaching. The AgriBoost® treatment greatly reduced the amount of P leached compared to all other treatments during the first 2 growing seasons (Tables 21a and 21b). The GSA ZK406H treatment decreased NO_3-N leaching significantly compared to the peat treatment during establishment (Table 15). The value of each of these reductions in nutrient leaching is specific to the needs of the individual construction site. The reduction of NO_3-N leaching attained by amending a root zone mix with GSA ZK406H pertained only to the three month establishment period, after which the leaching of NO_3-N from all treatments declined to a level 7 times lower than the NO_3-N concentration found in the irrigation water when common management practices were followed. However, P leaching increased with respect to time for most treatments and K leaching appeared to be relatively constant over time throughout the course of the study.

Many golf courses use a small on-site pond (often replenished by well water) as the irrigation water supply. The pond is also a reservoir for the drainage water from nearby putting greens. Long-term P loading from the drainage water will degrade the quality of the surface water, leading to a hypereutrophic system which invites costly renovations. Therefore, a putting green amendment with the potential to reduce P loads in the drainage water can be of enormous economic benefit to a golf course in this situation. Furthermore, golf courses discharging drainage water into streams running through the course may be subject to scrutiny by local, state, or national regulatory agencies. Amelioration costs could be substantial.

Economic Merits of the Root Zone Amendments

Historically, prices of inorganic amendments have been relatively high compared to organic amendments like peat. A typical 19-green construction project requires 5,352 m^3 of root zone mix (Moore, 1999). Using this figure to create a 90% sand 10% amendment mix (v/v), 535 m^3 of each amendment would be required. Figure 17 shows the cost of the amendments and mixes used in this study using Moore's (1999) calculations for amount of root zone mix needed. The costs do not include shipping or blending. There is little doubt that in this study the use of inorganic amendments greatly increased the total cost of the corresponding root zone mix. Interestingly, amending the mix with peat actually decreased the cost of the mix as the cost of peat was less than that of sand on a volume basis (blending costs aside). AgriBoost® was the least expensive of the inorganic materials used

- 40% and 60% less expensive than GSA ZK406H on a volume and weight basis respectively (Figure 17).

Nelson (2003) correctly reports that several researchers failed to show agronomic benefits from using inorganic amendments in place of peat and uses this as the basis for concluding that the use of inorganic amendments is not economically justifiable. However, the author failed to mention studies that have shown environmental benefits of using inorganic amendments. Although a price cannot be put on the 79% reduction in NO_3-N leaching during grow-in when GSA ZK406H was substituted as an amendment for peat in this study (Table 15), it is unfair to conclude that this benefit does not have any value to the turf industry. Similarly, the incorporation of AgriBoost® significantly reduced P leaching compared to all other treatments including peat over the first two seasons of this study (Figure 15). The value of such characteristics was alluded to in the previous section.

The root zone mixes did not differ significantly in pesticide or N and P fertilizer requirements. However, the AgriBoost® treatment required only a fraction of the K fertilizer needed by the other treatments to maintain adequate soil test K. During the 2003 season, soil test results indicated no need for K applications to the AgriBoost® green, whereas other greens received 195 kg K_2O ha^{-1} and soil tests still indicated the need for additional K. This translates into a significant economic savings not only in reductions in K fertilizer use, but also the labor required to make extra K applications.

In this study, the only economic variables that differed among treatments were the cost of root zone mix materials, and the K fertilizer requirement. The AgriBoost® green required 90% less fertilizer K in 2003 than all other treatments. Assuming a conservative

75% reduction in K fertilizer requirement each year for the life of the green (1 vs. 4 lb K_2O M^{-1}), and a price of $1.10 kg^{-1} K_2O, the fertilizer savings for 13,006 m^2 [from Nelson (2003)] of AgriBoost®-amended putting green surfaces compared to the other greens examined in this study would be $1050, $2100, and $4200 after 5, 10, and 20 years respectively.

During bentgrass grow-in, a 12 kg N ha^{-1} application was skipped on both zeolite treatments due to color differences among treatments. Although the economic savings was insignificant, reductions in fertilizer N use are known to increase root mass density. The enhancement of the root system is more valuable than the fertilizer savings.

Reductions in water use could contribute to economic savings in situations where the golf course uses municipal water for irrigation (urban areas). The results from the field volumetric moisture content measurement of the root zone mixes suggests that AgriBoost® has the potential to reduce water use compared to all other amendments. Laboratory moisture release curves indicate that peat is an effective amendment for increasing plant available water. Due to the limitations of the field irrigation system, treatment differences regarding water use were not quantified.

Based on the results from this research project, the substitution of inorganic materials in place of sphagnum peat is not warranted based on agronomic merits alone. However, in situations where a reduction in N or P leaching is necessary, the high initial cost of the inorganic-amended root zone mix is justified.

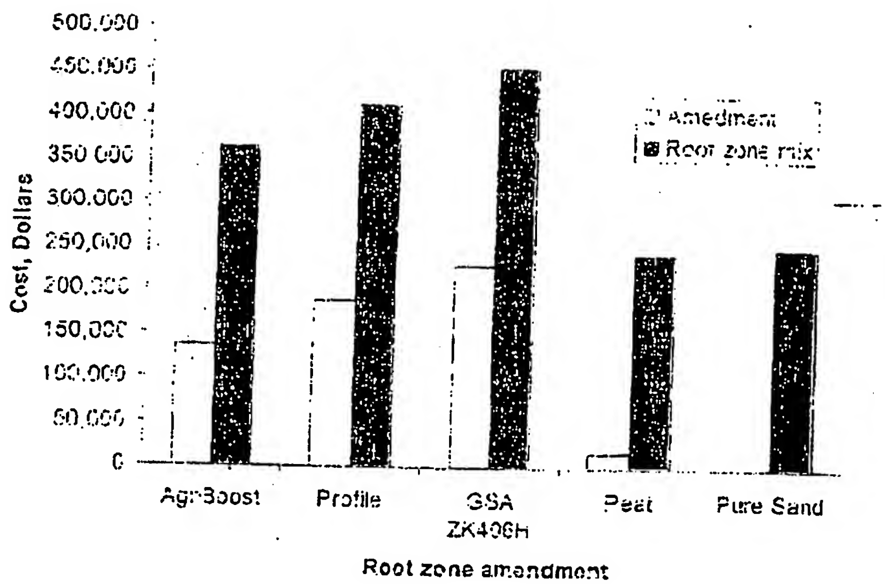

Figure 17. Cost of root zone mixes and amendments for a typical 19-green construction project.

Table 21a. Phosphorus leached in 2002.

Root zone mix	06/06	07/08	08/11	09/09	09/27	10/14	11/29	Total
	kg P ha^{-1}							
AgriBoost	0.13	0.32	0.15	0.12	0.09	0.10	0.12	1.03
Profile	2.17	3.48	1.16	1.11	0.88	1.06	1.27	11.13
GSA ZK406H	0.13	0.45	0.55	0.38	0.26	0.31	0.38	2.49
Peat	0.79	1.02	0.65	0.27	0.25	0.30	0.36	3.57
Pure Sand	0.53	0.67	0.54	0.45	0.32	0.38	0.45	3.34
$LSD_{0.05}$	1.37	2.42	0.73	0.43	0.27	0.32	0.31	4.46

Table 21b. Phosphorus leached in 2003.

Root zone mix	04/23	05/01	05/06	05/13	05/27	06/10	06/24	07/08	Total
	kg P ha^{-1}								
AgriBoost	0.17	0.14	0.23	0.24	0.21	0.31	0.23	0.29	1.8
Profile	1.27	2.40	2.68	3.06	2.43	3.34	3.24	2.80	21.2
GSA ZK406H	0.65	1.79	2.76	2.61	2.47	5.34	2.65	2.53	21.0
Peat	1.20	1.76	2.56	2.64	2.47	4.99	2.51	2.09	20.3
Pure Sand	1.00	1.68	2.61	2.59	2.42	5.03	2.57	2.26	20.5
$LSD_{0.05}$	0.63	0.62	0.50	0.70	0.65	0.88	0.82	0.48	4.13

Benefits of H2OLD in Growth Media for Ornamental Plant Production

Introduction

This trial with Golden Pothos (*Epipremnum aureum*, a leafy ornamental) was conducted by the Horticultural Research Station of Texas A&M University at Weslaco, TX. It was the object of the study to evaluate the nutritional effects of using H2OLD for ornamental production. The use of H2OLD as an ingredient in growth medium resulted in many nutritional benefits for plants. In ornamentals, better nutrient supply and uptake contribute directly to a more attractive appearance of the plants, which increases the plants' value. Based on the results discussed in detail below, the use of H2OLD clearly reduces or eliminates the risk of most nutrient deficiencies. Some nutrients, most notably P, are increased to a particular beneficial level by H2OLD. This high nutrient supply directly translates into healthier, better looking plants that reach a marketable state and size earlier than plants grown without H2OLD.

The trial was started on August 9, 2001, and plants were harvested for analysis in April 2002. Sunshine Mix #4 (a peat-based growth medium) was used that contains no pre-charged nutrients. Single-node, leaf-eye cuttings that were collected from stock plants were planted 15 each in six-inch plastic pots. There were five experimental treatments, all of which received the same fertilization with Peters 24-6-18 water-soluble foliage fertilizer at 100 ppm N.

Experimental Treatments:

Control: unamended growth medium
Micromax: growth medium plus Micromax, a commercial micronutrient fertilizer for ornamental plants.
H2OLD 5%: growth medium plus 5% H2OLD by volume
H2OLD 10%: growth medium plus 10% H2OLD by volume
H2OLD 15%: growth medium plus 15% H2OLD by volume

At the end of the experiment, length, fresh weight, leave number, total leaf area on the five longest vines in each pot were determined. The combined fresh weight of all 15 vines in a pot was recorded. Leachate samples were collected from pots for determining pH and electrical conductivity. Mineral concentration in the fifth distal leaves and pH and electrical conductivity of growth medium leachate samples were determined.

Results and Discussion

Effects on Plant and Leaf Sizes

Compared to the control, adding 5% or 10% H2OLD resulted in longer vines and greater total fresh weight, probably as a result of increased micronutrient supplies from H2OLD (see discussions below). Overall, H2OLD did not result in notable changes of plant or leaf size compared to the control. There was no visible injury or phytotoxicity at all H2OLD rates at the time of data collection.

The addition of Micromax in media resulted in greater leaf number on longer vines but decreased total leaf area per vine length, due to the **smaller** individual leaves on plants that received Micromax. Since large, showy leaves are desired for Golden Pothos, H2OLD is at a definite advantage over micronutrient fertilizers like Micromax.

Table 1. Number of Leaves, Vine Length, and Total Leaf Area
(averages of the longest five vines in each pot)

Treatment	No. of leaves	Vine length [cm]	Leaf area per vine length [cm^2 cm^{-1}]	Total fresh weight [g]
Control	12	56.8	8.36	467
H2OLD 5%13		68.4	6.64	551
H2OLD 10%	13	62.8	6.97	532
H2OLD 15%	12	54.4	7.46	455
Micromax	14	86.9	5.57	605

Effects on Macronutrient Contents

Plants growing in medium amended with H2OLD had increased contents of phosphorus, potassium, and calcium, outperforming those grown with Micromax and the control treatment.

Table 2. Macronutrient Levels in Golden Pothos Leaves

Treatment	N	P	K	Ca	Mg
	[leaf content as % dry weight]				
Control	4.70	0.49	4.20	2.08	0.83
H2OLD 5%4.47	0.57	4.30	2.10	0.84	
H2OLD 10%	4.35	0.65	5.12	2.15	0.84
H2OLD 15%	4.19	0.68	4.64	2.21	0.84
Micromax	5.05	0.32	4.30	1.96	0.87

H2OLD increased plant phosphorus content:
The increase in P content was truly dramatic: H2OLD treatments had up to 38% higher leaf P contents than the control. Micromax actually depressed leaf phosphorus content 35% below the control. In general, high phosphorus status benefits total plant development by speeding maturity. Of particular interest for ornamental production is the effect of P status on flowering. High phosphorus content leads to earlier flowering and to the creation and maintenance of more flowers. Another notable and highly beneficial effect is that despite high P uptake by the plants with H2OLD, zinc uptake was still adequate (see Zn results below). In most cases, growth media that provide superior phosphorus supply tend to markedly depress zinc uptake, leading to Zn deficiencies. This does not occur with H2OLD.

H2OLD increased plant potassium content:
The better K nutrition provided by H2OLD benefits plants mainly by improving osmoregulation. This gives plants better drought and heat resistance, which can help overcome occasional and unforeseen production problems. Potassium is also important for disease resistance. Increased potassium content can help ensure attractive plants despite periods of stress due to heat, scarce water, and disease pressure.

H2OLD increased plant calcium content:
Calcium is crucial for the development of strong cell walls. If Ca is deficient, plant tissues are soft, misshapen, and vulnerable to plant diseases, especially fungal diseases. H2OLD guards against these threats to ornamentals by providing an abundant supply of plant-available calcium.

H2OLD did not affect either pH or electrical conductivity of the medium leachate. This is important for ornamentals that only tolerate a narrow range of pH in their rooting medium.

Effects on Micronutrient Contents
H2OLD in the growth medium increased plant contents of iron (Fe), boron (B), manganese (Mn), and molybdenum (Mo). This again in most cases outperformed the control treatment and Micromax, the commercial micronutrient fertilizer.

H2OLD increased boron content:
Boron is an important micronutrient for cell division, tissue growth, and flower formation. When B is deficient, the developing tissues, in particular the vascular tissues, are retarded. This leads to stunted plants with misshapen leaves and stems. The younger plant parts also appear chlorotic (yellow), and flower development is disrupted or ceases completely. H2OLD provides a good

supply of boron to maintain normal tissue development and flower formation. This provides protection against unattractive and therefore not marketable plants.

H2OLD increases iron and manganese content:
If plants are deficient in iron and/or manganese, they are yellow from chlorosis and lack vigor. This is due to the critical role manganese and especially iron play in the synthesis of chlorophyll and other important components of the photosynthetic process. Good Fe-supply in particular gives plants a deep, lustrous dark-green color, making the foliage very attractive. This color cannot be achieved by just a high nitrogen supply if iron or manganese is deficient.

H2OLD increases molybdenum content:
H2OLD was at least as good as Micromax in providing Mo for the plants. Acid growth media in general and peat-based media in particular, are low to deficient in plant-available molybdenum. This can cause problems not only with legumes but with all plants if nitrate fertilizers are used. Plants require Mo to be able to use nitrate as a nitrogen source, due to molybdenum's central role in the enzyme nitrate reductase. Without it, plants cannot convert nitrate into usable forms and thus become N-deficient.

Table 3. Micronutrient Levels in Golden Pothos Leaves

Treatment	B	Fe	Mn	Zn	Mo
			[mg kg^{-1}]		
Control	34	83	211	51	6.4
H2OLD 5%	35	87	165	36	9.1
H2OLD 10%	34	112	256	31	9.0
H2OLD 15%	40	91	329	45	10.8
Micromax	29	86	256	129	10.4

H2OLD has again proven itself as a low-cost amendment that conveniently provides a range of benefits that otherwise can only be obtained by using several products in a more complicated management system. For ornamental production, H2OLD provides the following benefits:

Adequate nutrient supplies across the board
Increased plant nutrition for the macronutrients P, K, and Ca
Increased plant nutrition for the micronutrients B, Fe, Mn, and Mo
pH-buffering of the growth medium

All this from one simple-to-use, certified organic, non-toxic and all-natural product. The results are more flowers that are more attractive in less time.

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FiBL

Effects of AgriBoost on the production of transplants

First results

Martin Koller and Thomas Alföldi

April 2002, Frick Switzerland

Introduction

In 2001 FiBL has carried out a first experiment with AgriBoost amendment in potting earth. The results were:

- AgriBoost enhanced the growth of cauliflower and tomato plantlets
- AgriBoost has a greater effect without compost
- AgriBoost enhanced the uptake of several minerals: For both crops N, Mg, Ca and B; additional for tomatoes Fe, Zn, Cu, P and K

Aims of the present experiment:
The aim of this trial is to test the effect of AgriBoost in transplants production under the following conditions:

- Different concentrations of AgriBoost in the substrate (5%, 10%)
- AgriBoost compared with other commercial rock and clay powder
- AgriBoost under plastic pot and peat pot conditions
- AgriBoost in different commercial substrate types

We measured fresh weight of the test plant and selected characteristics of the potting media.

Material and Methods

Test crop: Tomato (*Lycopersicon esculentum*) cv. "Cristal"

Replicates: Plastic pots: 6 with 3-4 plants (n=20 per treatment)
Peat pot: 2 with 10 plants (n=20 per treatment)

Treatments:

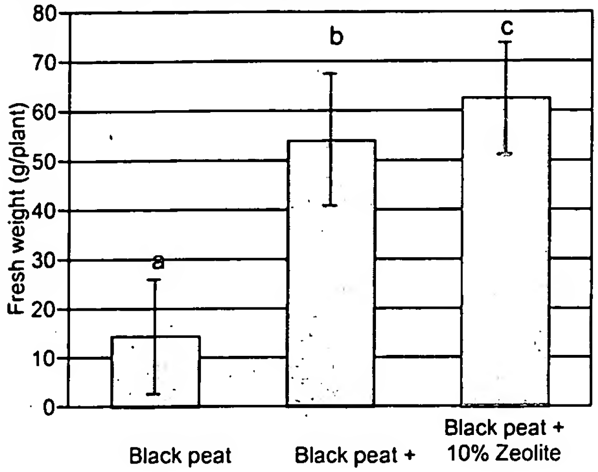
Treat-ment	Growing media	Clay-mineral	Concentration in %	Pots
V-1	Black peat + lime and NPK (*)	AgriBoost	0	12 cm plastic pot
V-2	Black peat + lime and NPK (*)	AgriBoost	5	12 cm plastic pot
V-3	Black peat + lime and NPK (*)	AgriBoost	10	12 cm plastic pot
V-4	Triohum Potgrond H (or P)	AgriBoost	0	12 cm plastic pot
V-5	Triohum Potgrond H (or P)	AgriBoost	10	12 cm plastic pot
V-6	Triohum Potgrond H (or P)	Bentonite	10	12 cm plastic pot
V-7	Triohum Potgrond H (or P)	Rock powder	10	12 cm plastic pot
V-8	Klasmann KKS Bio-Potgrond	AgriBoost	0	12 cm plastic pot
V-9	Klasmann KKS Bio-Potgrond	AgriBoost	10	12 cm plastic pot

(*) Per m^3: 10 kg lime, 0.75 kg ammonium nitrate (27%), 0.55 kg phosphate fertiliser (basic slag, 17 %) and 0.8 kg sulphate of potash

Triohum Potgrond H & P and *Klasman KKS Bio-Potgrond* are commercial potting mixes.

Results and Discussion

Fresh weight of the test plant



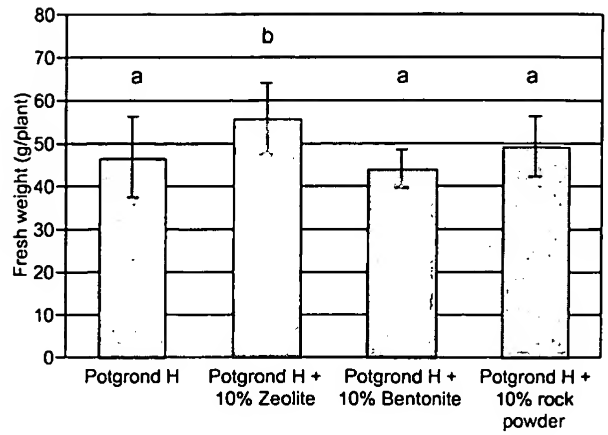


Fig. 1: Fresh weight of tomato plantlets with 0, 5 and 10 % of AgriBoost in black peat (n=20, $p < 0.001$, Tukey α= 0.05)

Fig. 2: Fresh weight of tomato plantlets, with 10 % AgriBoost, bentonite and rock powder in commercial, conventional growing media (n=20, $p < 0.001$, Tukey α= 0.05)

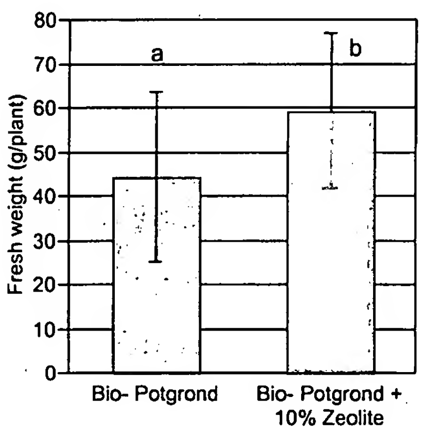


Fig. 3: Fresh weight of tomato plantlets with and without AgriBoost in organic potting media (n=20, $p < 0.001$, Tukey α= 0.05)

First Conclusions

- AgriBoost increased the fresh weight of tomato plantlets
- Effect of AgriBoost in commercial potting media is lower than in black peat lime mixture
- Other clay (Bentonite) and rock powder did not shown an effect

Charateristics of potting media

Tab. 1 Potting media parameters before the experiment

Potting media ad clay or rock powder	weight / volume	pH	conductivity mS/cm	dry matter (%)
Black peat	0.65	6.35	1.82	23%
Black peat + 5% AgriBoost	0.70	6.50	1.70	29%
Black peat + 10% AgriBoost	0.75	6.55	1.80	34%
Potgrond H	0.52	5.85	1.71	28%
Potgrond H + 10% AgriBoost	0.60	6.50	1.70	42%
Potgrond H + 10% Bentonite	0.57	6.10	1.49	36%
Potgrond H + 10% rock powder	0.60	6.40	1.63	40%
Bio- Potgrond	0.68	5.15	2.31	36%
Bio- Potgrond + 10% AgriBoost	0.74	5.95	2.00	46%

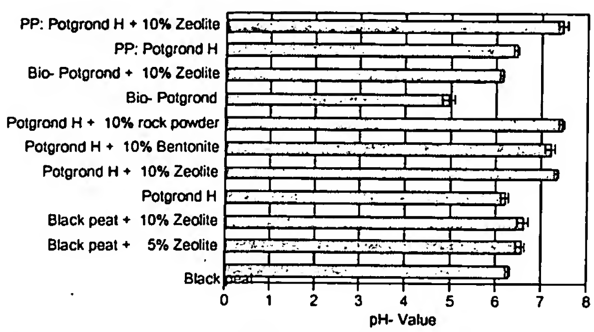


Fig. 5: pH Value of different potting media with and without AgriBoost after experiment (n=4)

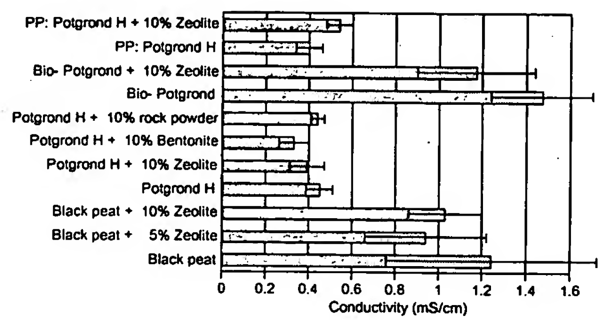


Fig. 6: Conductivity of different potting media with and without AgriBoost after experiment (n=4)

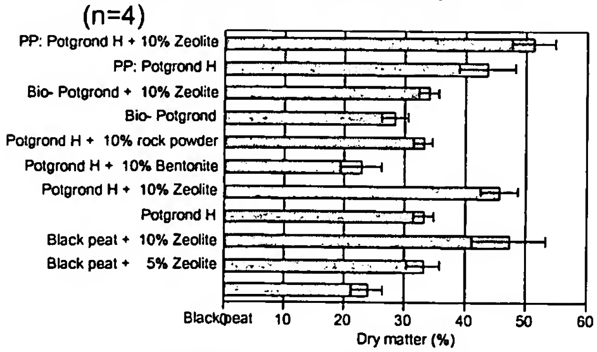


Fig. 7: Dry matter content of different potting media with and without AgriBoost after experiment (n=4)

First Conclusions

- pH of the potting media with AgriBoost has significantly increased
- Dry matter of the potting media with AgriBoost significantly increased
- Conductivity: Small difference between the comparable treatments (no difference in black peat treatments, with Potgrond H and Bio-Potgrond sig. decreasing with AgriBoost)